

REMARKS

This Preliminary Amendment cancels without prejudice claims 1 to 10 in the underlying PCT Application No. PCT/DE02/04290, and adds without prejudice new claims 11 to 20. The new claims, *inter alia*, conform the claims to U.S. Patent and Trademark Office rules and do not add new matter to the application.



In accordance with 37 C.F.R. § 1.125(b), the Substitute Specification (including the Abstract) contains no new matter. The amendments reflected in the Substitute Specification (including Abstract) are to conform the Specification and Abstract to United States Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. §§ 1.121(b)(3)(ii) and 1.125(c), a Marked-Up Version of the Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. Approval and entry of the Substitute Specification (including Abstract) are respectfully requested.

The underlying PCT Application No. PCT/DE02/04290 includes an International Search Report, dated May 7, 2003. The Search Report includes a list of documents that were uncovered in the underlying PCT Application. A copy of the Search Report accompanies this Preliminary Amendment.

It is asserted that the subject matter of the present application is new, non-obvious, and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully Submitted,
KENYON & KENYON

Dated: 7/8/04

By:  (by
Richard L. Mayer
Reg. No. 22,490

H. no.
36,177)

One Broadway
New York, NY 10004
(212) 425-7200
(212) 425-5288

CUSTOMER NO. 26646

METHOD AND DEVICE FOR RECOGNIZING
VISUAL OBSTRUCTIONS IN IMAGE SENSOR SYSTEMS

~~Background Information~~

FIELD OF THE INVENTION

The present invention relates to a method and to a device for recognizing visual obstructions in image sensor systems.

5

BACKGROUND INFORMATION

In the future, in particular in conjunction with environmental sensing of motor vehicles, image sensors such as video cameras, for example, ~~will~~ may be used whose image is
10 evaluated by downstream functions (driver assistance functions, for example). It is therefore of particular importance to recognize visual obstructions which degrade the image detected by the image sensor, to inform the downstream functions or systems of the presence of such visual
15 obstructions, and to initiate countermeasures, if necessary.

~~Advantages of the Invention~~

SUMMARY OF THE INVENTION

The detection of the blurriness of the recorded image results
20 in a suitable ~~procedure~~ method which assists in recognizing visual obstructions. ~~It is particularly advantageous that downstream~~ Downstream systems or functions, which function properly only when the view is adequate, ~~are~~ may be informed of the presence of the visual obstruction and are thus able to
25 initiate suitable countermeasures. When a visual obstruction is recognized, depending on the ~~design~~ configuration of the downstream function or system, the recorded image is ~~advantageously~~ not evaluated or corrected, or other suitable measures, such as switching on the windshield wiper system or
30 windshield heating, for example, are performed.

~~It is particularly advantageous that visual~~ Visual
obstructions ~~are~~ may be recognized based on the image signal
itself, so that no additional sensors are necessary.

5 The ~~procedure~~ method is suitable in particular for recognizing
a visual obstruction on the windshield of the motor vehicle.

The image sensor ~~advantageously takes over~~ assumes additional
functions, such as the function of a rain sensor, for example,
10 so that this additional rain sensor may be dispensed with in
the ~~furnishing of the~~ vehicle with such image sensor-based
driver assistance functions, for example lane monitoring
systems.

15 The ~~procedure~~ method described below ~~is~~ may be used in ~~a~~
~~particularly advantageous manner~~ in video sensor systems in
motor vehicles, which systems are not focused on the vehicle
windshield, but rather on the external region. The ~~procedure~~
method described below may thus be used ~~to particular~~
20 ~~advantage~~ in conjunction with the sensing of the environment
around a motor vehicle. In this manner the image sensor may be
used for multiple applications (for example, rain sensor and
object detection, etc.).

25 ~~It is also advantageous that the~~ The image sensor ~~is~~ may be
able to check its functionality using its own output signal,
i.e., ~~to~~ determine whether the instantaneous view conditions
are sufficient for the next function that is to be performed.
When the image sensor is not functioning properly, this is
30 ~~advantageously~~ signaled to the driver or the downstream
system, and/or countermeasures are taken.

~~It has been shown in a particularly advantageous manner that~~
~~the~~ The detection of visual obstructions ~~is~~ may be performed
35 by measuring the blurriness of the represented image. A
reliable method ~~is thus~~ may be provided for determining visual
obstructions, in particular objects on a vehicle windshield,

which appear blurry in the image. ~~It is particularly~~
~~advantageous that transparent~~ Transparent objects such as
raindrops, or semitransparent objects such as ice or dust, for
example, ~~are~~ may be recognized, and in one particular
5 exemplary embodiment even distinguished from one another, by
measuring the blurriness of the image.

Thus, ~~it is also advantageously possible to obtain~~ information
may be obtained about the type of visual obstructions. In this
10 manner, a response specific to the particular type of visual
obstruction may be made, for example by automatically
switching on the windshield washer system when the windshield
is soiled by particles.

15 ~~Further advantages arise from the following description of~~
~~exemplary embodiments and the dependent claims.~~

Drawing

20 ~~The present invention is explained in greater detail below~~
~~with reference to the exemplary embodiments illustrated in the~~
~~drawing.~~

BRIEF DESCRIPTION OF THE DRAWINGS

25 Figure 1 shows ~~an overview~~ a schematic illustration of an
image sensor system ~~in by which the procedure~~ a method
~~described below~~ according to the present invention for
determining visual obstructions is implemented, ~~and.~~

30 ~~Figures 2 through 4 show diagrams with reference to which~~
~~three different embodiments~~

Figures 2a and 2b show charts illustrating an exemplary
embodiment of the method for determining the blurriness in the
35 image and the recognition of visual obstructions derived
therefrom ~~are described.~~

Figures 3a and 3b show charts illustrating another exemplary embodiment of the method for determining the blurriness in the image and the recognition of visual obstructions derived therefrom.

Figures 4a and 4b show charts illustrating another exemplary embodiment of the method for determining the blurriness in the image and the recognition of visual obstructions derived therefrom.

~~Description of the Exemplary Embodiments~~

DETAILED DESCRIPTION

The image sensor system illustrated in Figure 1 ~~is composed essentially of~~ includes an optical sensor array 3 which is connected to a data processing unit (or an evaluation unit) 7, for example a microprocessor. The instantaneously visible scene is mapped onto the sensor array 3 by a lens system 2. The image sensor is mounted behind a windshield 1 and is focused on ~~the an~~ an external region ~~behind~~ beyond the windshield. The windshield is, for example, the window glass of a vehicle, in particular the windshield of the vehicle. The focusing on the vehicle's external region allows the image sensor system to also be used for other image processing operations such as lane detection or obstruction detection, for example. Evaluation unit 7 ~~is composed of~~ includes a module 4 for controlling lighting of the sensor array, a measuring unit 5 for estimating blurriness, and a decision module 6 which makes decisions regarding the presence and, optionally, the type, of a visual obstruction. In one ~~preferred exemplary~~ exemplary embodiment all of these modules are part of a microprocessor, the modules being implemented as software programs. In other exemplary embodiments, the modules are individual components (processors), ~~likewise~~ implemented as software, where estimations of blurriness are made, for example, in one component and decisions are made in another component. The decision made by decision module 6 is then

relayed as an information and/or activation signal to downstream functions and/or systems. ~~Application possibilities are described in greater detail below.~~

5 The automatic detection of visual obstructions on the windshields of a vehicle ~~therefore~~ plays an increasingly important role due to the fact that, when image sensors are used in the vehicle, systems which evaluate the images from the sensor function properly only when the view is adequate.
10 If there is information about the visual obstruction and, in the ideal case, about the type of visual obstruction, such a system is able to display to the driver its instantaneous lack of functionality and/or to take countermeasures, such as switching on the wiper system, the windshield heating system,
15 or the windshield washer system, for example.

When visual obstructions are determined based solely on the image sensor signal, the problem arises that visual obstructions on a vehicle windshield are made noticeable in
20 the image only indirectly, since ~~for use~~ in driver assistance systems the image sensor is focused on the vehicle's external region. Objects on the windshield, for example raindrops or dust, are therefore blurrily imaged. These visual obstructions are thus made noticeable by a characteristic distribution of
25 the blurriness in the image signal.

The detection of visual obstructions is based on measuring the blurriness of the image which is recorded by an image sensor. This blurriness is made noticeable by a lack of sharpness of
30 the imaged contours of the instantaneously visible scene. Objects present on the windshield are blurrily imaged due to the focusing of the image sensor on the external region. Transparent objects, such as raindrops, for example, result in localized defocusing of the image, and semitransparent objects
35 such as ice or dust scatter incident light beams. Both effects result in an increase in the blurriness of the sensor signal. The evaluation unit which is associated with the image sensor,

an optical sensor array of, for example, a CCD or CMOS camera, detects the distribution of blurriness of the instantaneously imaged scene. Based on the detected distribution of blurriness, a conclusion is drawn as to the presence of a visual obstruction. ~~One of the~~ The methods for digital image processing described below ~~is~~ may be used for determining the blurriness.

In one ~~preferred~~ exemplary embodiment, the image sensor is a sensor array which assists in obtaining information also on the type of visual obstruction. This fundamentally distinguishes such a sensor array from a conventional rain sensor which operates by the reflection principle. The use of a sensor array allows a specific response to be initiated in response to the determined visual obstruction by, for example, by additionally switching on a windshield washer system for washing soiling caused by particles. One ~~preferred procedure~~ exemplary method for recognizing the type of visual obstruction is ~~likewise~~ described in detail below.

A first possibility for measuring blurriness is illustrated with reference to the diagrams in ~~Figure 2~~ Figures 2a and 2b. Blurriness is measured here using the contrast spectrum. The underlying principle of this method is known from the field of digital image processing. To obtain the contrast spectrum, first a multiscale analysis is ~~carried out~~ performed, in which the video image is decomposed into multiple images of decreasing resolution by the repeated use of a smoothing operation and subsequent subsampling. A global measure of contrast, for example the standard deviation of the intensity values in the image, is calculated in each resolution stage. The measure of contrast plotted as a function of the resolution forms the contrast spectrum of the image. Examples of such contrast spectra are shown in Figures 2a and 2b. In these figures, the particular measure of contrast K of the image is plotted as a function of resolution A . Sharp and blurry images differ in their contrast spectra by the fact

that the drop in contrast as a function of increasing resolution is steeper in blurry images than in sharp images. This is because fine details are degraded more strongly by visual obstructions than are coarse image features. Thus, the drop in the contrast spectrum is a measure of the blurriness of the image. ~~Situations are shown as examples in Figures 2a and 2b.~~ Figure 2a illustrates a contrast spectrum as a function of the image resolution for an image with slight blurriness, while Figure 2b shows the situation for high image blurriness (blurry image).

In one implementation of the procedure method for determining the blurriness of the image, the contrast spectrum is recorded by multiscale analysis within a computing program, and a variable is determined, for example the average increase in the measure of contrast as a function of the resolution, which characterizes the variation of the measure of contrast as a function of the resolution. The blurriness of the image is determined by comparing this variable to at least one limiting value. For recognizing a visual obstruction, in particular with regard to the response measures planned in the downstream systems, it is sufficient to determine that the image is blurry[[;]]. ~~thus~~ Thus, the determined variable is compared to a limiting value, and if this limiting value is exceeded, blurriness may be assumed, or the variable itself is relayed as a measure of blurriness. In other applications, determining a measure of the blurriness ~~is~~ may be desired. In these cases, limiting values form ranges for the variable which characterizes the contrast spectrum and to which blurriness values are assigned. A value for the magnitude of the blurriness is determined when the value characterizing the contrast spectrum is in a specified range of values.

In addition to measuring the blurriness by using the contrast spectrum, there are a number of other methods from the field of digital image processing that may be used to detect blurriness. Examples of such alternative methods for measuring

the image blurriness are measures for analyzing the Fourier spectrum or the autocorrelation of the analyzed image. In the Fourier spectrum a blurry image is characterized by the fact that the amplitudes of the high spatial frequencies, which represent the finer image details, are strongly attenuated in comparison to a sharp image.

Examples of such a situation are shown in Figures 3a and 3b. The curve of the Fourier spectrum is plotted in both figures, the amplitude of the Fourier transformation function being represented by the spatial frequency. Figure 3a shows a slightly blurry image, while Figure 3b shows a highly blurry image. It is obvious that the amplitudes at the higher spatial frequency decrease greatly for a blurry image. For evaluation, in one ~~preferred exemplary~~ embodiment ~~it is therefore provided of the present invention provides~~ that the amplitude and the corresponding spatial frequency are used to recognize values that fall below a threshold value. If this spatial frequency is below a predetermined value, it is assumed that the image is blurry. In another exemplary embodiment, the slope of the curve could also be used here to determine blurriness by comparing it to at least one limiting value. For the evaluation of the Fourier spectrum as well, ~~it is possible to determine~~ a value for the magnitude of blurriness may be determined by specifying multiple limiting values or by specifying value ranges, and relaying this value to downstream systems.

A third possibility for measuring blurriness is the autocorrelation function of the image. This autocorrelation function decreases less steeply for a blurry image than for a sharp image as a function of distance. This is because only large structures remain in a blurry image. ~~Figure 4 illustrates~~ Figures 4a and 4b illustrate this relationship, the particular magnitude of the autocorrelation function being plotted as a function of the pixel separation. Figure 4a shows the autocorrelation function for a slightly blurry image, and

Figure 4b shows the autocorrelation function for a highly blurry image. The figures show that as the pixel spacing for an image having a low degree of blurriness (sharp image) increases, the autocorrelation function rapidly decreases, whereas for a blurry image the decrease in the autocorrelation function is less pronounced. As indicated above, for the evaluation it is possible to use at least one limiting value or multiple limiting values being exceeded or not being attained, or, in another exemplary embodiment, to use the calculated average increase to determine the blurriness and/or to determine a value for the magnitude of the blurriness.

A further alternative for measuring blurriness ~~is~~ may be provided by an indirect classification formulation in which a learning machine, a neural network or a polynomial classifier, for example, is trained to distinguish between blurry and sharp images by presenting a large number of images as examples.

As mentioned above, a visual obstruction is assumed when a high degree of blurriness is recognized, or the value of the blurriness is greater than a predetermined value. In addition, a comparison to reference distributions for contrasts, Fourier components, or autocorrelations may differentiate various types of visual obstructions based on their similarity to specific reference distributions. In this manner ~~it is possible to distinguish~~, moisture on the windshield may be distinguished from ice or dust on the windshield, and, depending on the situation, to initiate different countermeasures, for example, activation of the windshield wiper, switching on a windshield heating system or a windshield washer system, etc. Here as well, the above-referenced classification formulation may be provided by learning machines.

If the video sensor having visual obstruction detection is also operated as a rain sensor, further ~~additions are~~ useful

applications are possible. If moisture on the windshield is recognized based on the determined blurriness and the contrast distribution, or the Fourier spectrum or autocorrelation, the windshield wiper is, as previously, initially actuated only at the explicit request of the driver, to prevent erroneous start-up when an error is detected. Using the video images which are recorded immediately after the wiping operation, ~~it is possible to obtain~~ the above-mentioned reference distributions may be obtained, using which a decision is made to initiate the next wiping operation. Thus, the wiping response may be adapted on a situation-specific basis. For situations in which the surrounding scene contains too little contrast, it may be practical to temporarily switch on a windshield light. Visual obstructions are then detectable from the scattering of the light.

Abstract

ABSTRACT OF THE DISCLOSURE

A method and a device for recognizing visual obstructions in image sensor systems are ~~proposed,~~ provided. ~~a~~ A signal ~~being~~ is produced, based on the analysis of the recorded image from the image sensor, which indicates the presence and, optionally, the type, of the visual obstruction on a windshield, for example.

~~(Figure 1)~~

METHOD AND DEVICE FOR RECOGNIZING
VISUAL OBSTRUCTIONS IN IMAGE SENSOR SYSTEMS

FIELD OF THE INVENTION

The present invention relates to a method and a device for recognizing visual obstructions in image sensor systems.

5 BACKGROUND INFORMATION

In the future, in particular in conjunction with environmental sensing of motor vehicles, image sensors such as video cameras, for example, may be used whose image is evaluated by downstream functions (driver assistance functions, for
10 example). It is therefore of particular importance to recognize visual obstructions which degrade the image detected by the image sensor, to inform the downstream functions or systems of the presence of such visual obstructions, and to initiate countermeasures, if necessary.

15 SUMMARY OF THE INVENTION

The detection of the blurriness of the recorded image results in a suitable method which assists in recognizing visual obstructions. Downstream systems or functions, which function properly only when the view is adequate, may be informed of
20 the presence of the visual obstruction and are thus able to initiate suitable countermeasures. When a visual obstruction is recognized, depending on the configuration of the downstream function or system, the recorded image is not
25 evaluated or corrected, or other suitable measures, such as switching on the windshield wiper system or windshield heating, for example, are performed.

Visual obstructions may be recognized based on the image
30 signal itself, so that no additional sensors are necessary.

The method is suitable in particular for recognizing a visual obstruction on the windshield of the motor vehicle.

The image sensor assumes additional functions, such as the function of a rain sensor, for example, so that this additional rain sensor may be dispensed with in the vehicle with such image sensor-based driver assistance functions, for example lane monitoring systems.

The method described below may be used in video sensor systems in motor vehicles, which systems are not focused on the vehicle windshield, but rather on the external region. The method described below may thus be used in conjunction with the sensing of the environment around a motor vehicle. In this manner the image sensor may be used for multiple applications (for example, rain sensor and object detection, etc.).

The image sensor may be able to check its functionality using its own output signal, i.e., determine whether the instantaneous view conditions are sufficient for the next function that is to be performed. When the image sensor is not functioning properly, this is signaled to the driver or the downstream system, and/or countermeasures are taken.

The detection of visual obstructions may be performed by measuring the blurriness of the represented image. A reliable method may be provided for determining visual obstructions, in particular objects on a vehicle windshield, which appear blurry in the image. Transparent objects such as raindrops, or semitransparent objects such as ice or dust, for example, may be recognized, and in one exemplary embodiment even distinguished from one another, by measuring the blurriness of the image.

Thus, information may be obtained about the type of visual obstructions. In this manner, a response specific to the particular type of visual obstruction may be made, for example

by automatically switching on the windshield washer system when the windshield is soiled by particles.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a schematic illustration of an image sensor system by which a method according to the present invention for determining visual obstructions is implemented.

Figures 2a and 2b show charts illustrating an exemplary embodiment of the method for determining the blurriness in the image and the recognition of visual obstructions derived therefrom.

Figures 3a and 3b show charts illustrating another exemplary embodiment of the method for determining the blurriness in the image and the recognition of visual obstructions derived therefrom.

Figures 4a and 4b show charts illustrating another exemplary embodiment of the method for determining the blurriness in the image and the recognition of visual obstructions derived therefrom.

DETAILED DESCRIPTION

The image sensor system illustrated in Figure 1 includes an optical sensor array 3 which is connected to a data processing unit (or an evaluation unit) 7, for example a microprocessor. The instantaneously visible scene is mapped onto the sensor array 3 by a lens system 2. The image sensor is mounted behind a windshield 1 and is focused on an external region beyond the windshield. The windshield is, for example, the window glass of a vehicle, in particular the windshield of the vehicle. The focusing on the vehicle's external region allows the image sensor system to also be used for other image processing operations such as lane detection or obstruction detection, for example. Evaluation unit 7 includes a module 4 for controlling lighting of the sensor array, a measuring unit 5

for estimating blurriness, and a decision module 6 which makes decisions regarding the presence and, optionally, the type, of a visual obstruction. In one exemplary embodiment all of these modules are part of a microprocessor, the modules being
5 implemented as software programs. In other exemplary embodiments, the modules are individual components (processors), implemented as software, where estimations of blurriness are made, for example, in one component and decisions are made in another component. The decision made by
10 decision module 6 is then relayed as an information and/or activation signal to downstream functions and/or systems.

The automatic detection of visual obstructions on the windshields of a vehicle plays an important role due to the
15 fact that, when image sensors are used in the vehicle, systems which evaluate the images from the sensor function properly only when the view is adequate. If there is information about the visual obstruction and, in the ideal case, about the type of visual obstruction, such a system is able to display to the
20 driver its instantaneous lack of functionality and/or to take countermeasures, such as switching on the wiper system, the windshield heating system, or the windshield washer system, for example.

25 When visual obstructions are determined based solely on the image sensor signal, the problem arises that visual obstructions on a vehicle windshield are made noticeable in the image only indirectly, since in driver assistance systems the image sensor is focused on the vehicle's external region.
30 Objects on the windshield, for example raindrops or dust, are therefore blurrily imaged. These visual obstructions are thus made noticeable by a characteristic distribution of the blurriness in the image signal.

35 The detection of visual obstructions is based on measuring the blurriness of the image which is recorded by an image sensor. This blurriness is made noticeable by a lack of sharpness of

the imaged contours of the instantaneously visible scene.

Objects present on the windshield are blurrily imaged due to the focusing of the image sensor on the external region.

Transparent objects, such as raindrops, for example, result in localized defocusing of the image, and semitransparent objects such as ice or dust scatter incident light beams. Both effects result in an increase in the blurriness of the sensor signal. The evaluation unit which is associated with the image sensor, an optical sensor array of, for example, a CCD or CMOS camera, detects the distribution of blurriness of the instantaneously imaged scene. Based on the detected distribution of blurriness, a conclusion is drawn as to the presence of a visual obstruction. The methods for digital image processing described below may be used for determining the blurriness.

In one exemplary embodiment, the image sensor is a sensor array which assists in obtaining information also on the type of visual obstruction. This fundamentally distinguishes such a sensor array from a conventional rain sensor which operates by the reflection principle. The use of a sensor array allows a specific response to be initiated in response to the determined visual obstruction by, for example, by additionally switching on a windshield washer system for washing soiling caused by particles. One exemplary method for recognizing the type of visual obstruction is described in detail below.

A first possibility for measuring blurriness is illustrated with reference to the diagrams in Figures 2a and 2b.

Blurriness is measured here using the contrast spectrum. The underlying principle of this method is known from the field of digital image processing. To obtain the contrast spectrum, first a multiscale analysis is performed, in which the video image is decomposed into multiple images of decreasing resolution by the repeated use of a smoothing operation and subsequent subsampling. A global measure of contrast, for example the standard deviation of the intensity values in the image, is calculated in each resolution stage. The measure of

contrast plotted as a function of the resolution forms the contrast spectrum of the image. Examples of such contrast spectra are shown in Figures 2a and 2b. In these figures, the particular measure of contrast K of the image is plotted as a function of resolution A . Sharp and blurry images differ in their contrast spectra by the fact that the drop in contrast as a function of increasing resolution is steeper in blurry images than in sharp images. This is because fine details are degraded more strongly by visual obstructions than are coarse image features. Thus, the drop in the contrast spectrum is a measure of the blurriness of the image. Figure 2a illustrates a contrast spectrum as a function of the image resolution for an image with slight blurriness, while Figure 2b shows the situation for high image blurriness (blurry image).

In one implementation of the method for determining the blurriness of the image, the contrast spectrum is recorded by multiscale analysis within a computing program, and a variable is determined, for example the average increase in the measure of contrast as a function of the resolution, which characterizes the variation of the measure of contrast as a function of the resolution. The blurriness of the image is determined by comparing this variable to at least one limiting value. For recognizing a visual obstruction, in particular with regard to the response measures planned in the downstream systems, it is sufficient to determine that the image is blurry. Thus, the determined variable is compared to a limiting value, and if this limiting value is exceeded, blurriness may be assumed, or the variable itself is relayed as a measure of blurriness. In other applications, determining a measure of the blurriness may be desired. In these cases, limiting values form ranges for the variable which characterizes the contrast spectrum and to which blurriness values are assigned. A value for the magnitude of the blurriness is determined when the value characterizing the contrast spectrum is in a specified range of values.

In addition to measuring the blurriness by using the contrast spectrum, there are a number of other methods from the field of digital image processing that may be used to detect blurriness. Examples of such alternative methods for measuring the image blurriness are measures for analyzing the Fourier spectrum or the autocorrelation of the analyzed image. In the Fourier spectrum a blurry image is characterized by the fact that the amplitudes of the high spatial frequencies, which represent the finer image details, are strongly attenuated in comparison to a sharp image.

Examples of such a situation are shown in Figures 3a and 3b. The curve of the Fourier spectrum is plotted in both figures, the amplitude of the Fourier transformation function being represented by the spatial frequency. Figure 3a shows a slightly blurry image, while Figure 3b shows a highly blurry image. It is obvious that the amplitudes at the higher spatial frequency decrease greatly for a blurry image. For evaluation, one exemplary embodiment of the present invention provides that the amplitude and the corresponding spatial frequency are used to recognize values that fall below a threshold value. If this spatial frequency is below a predetermined value, it is assumed that the image is blurry. In another exemplary embodiment, the slope of the curve could also be used here to determine blurriness by comparing it to at least one limiting value. For the evaluation of the Fourier spectrum as well, a value for the magnitude of blurriness may be determined by specifying multiple limiting values or by specifying value ranges, and relaying this value to downstream systems.

A third possibility for measuring blurriness is the autocorrelation function of the image. This autocorrelation function decreases less steeply for a blurry image than for a sharp image as a function of distance. This is because only large structures remain in a blurry image. Figures 4a and 4b illustrate this relationship, the particular magnitude of the autocorrelation function being plotted as a function of the

pixel separation. Figure 4a shows the autocorrelation function for a slightly blurry image, and Figure 4b shows the autocorrelation function for a highly blurry image. The figures show that as the pixel spacing for an image having a low degree of blurriness (sharp image) increases, the autocorrelation function rapidly decreases, whereas for a blurry image the decrease in the autocorrelation function is less pronounced. As indicated above, for the evaluation it is possible to use at least one limiting value or multiple limiting values being exceeded or not being attained, or, in another exemplary embodiment, to use the calculated average increase to determine the blurriness and/or to determine a value for the magnitude of the blurriness.

A further alternative for measuring blurriness may be provided by an indirect classification formulation in which a learning machine, a neural network or a polynomial classifier, for example, is trained to distinguish between blurry and sharp images by presenting a large number of images as examples.

As mentioned above, a visual obstruction is assumed when a high degree of blurriness is recognized, or the value of the blurriness is greater than a predetermined value. In addition, a comparison to reference distributions for contrasts, Fourier components, or autocorrelations may differentiate various types of visual obstructions based on their similarity to specific reference distributions. In this manner, moisture on the windshield may be distinguished from ice or dust on the windshield, and, depending on the situation, to initiate different countermeasures, for example, activation of the windshield wiper, switching on a windshield heating system or a windshield washer system, etc. Here as well, the above-referenced classification formulation may be provided by learning machines.

If the video sensor having visual obstruction detection is also operated as a rain sensor, further useful applications

are possible. If moisture on the windshield is recognized based on the determined blurriness and the contrast distribution, or the Fourier spectrum or autocorrelation, the windshield wiper is, as previously, initially actuated only at the explicit request of the driver, to prevent erroneous start-up when an error is detected. Using the video images which are recorded immediately after the wiping operation, the above-mentioned reference distributions may be obtained, using which a decision is made to initiate the next wiping operation. Thus, the wiping response may be adapted on a situation-specific basis. For situations in which the surrounding scene contains too little contrast, it may be practical to temporarily switch on a windshield light. Visual obstructions are then detectable from the scattering of the light.

ABSTRACT OF THE DISCLOSURE

A method and a device for recognizing visual obstructions in image sensor systems are provided. A signal is produced, based on the analysis of the recorded image from the image sensor, which indicates the presence and, optionally, the type, of the visual obstruction on a windshield, for example.

5